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BMP Longevity: A Pilot Study

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Alon Rosenthal and Don Urban

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BMP Longevity: A Pilot Study

The report is part of the National Network for Environmental Management Studies under the auspices of the Office of Cooperative Environmental Management of the U.S. Environmental Protection Agency. This study considers BMP longevity, focusing on five practices: terraces, animal waste storage, vegetative strips, waterways, and conservation district and local SCS personnel across the nation.

Study results suggest that existing Soil Conservation Service life expectancies may be too conservative and that many practices can last indefinitely if properly maintained.

The O&M activities required by different BMPs varies among practices. For vegetative practices,particularly waterways, the most important ones are passive "precautionary measures" which do not require additional spending. Similarly, both human and environmental factors affect different BMP's longevity. In some cases operators' education and environmental attitudes are viewed as having the greatest influence on a BMP's life span.

Operation and maintenance activities hold the key to long term water quality improvement and should increasingly become central objectives of nonpoint programs.

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Al Rosenthal
Don Urban

Executive Summary

There is relatively little information about the performance of agricultural practices that control nonpoint source runoff after they have been installed for several years. This study considers BMP longevity, focusing on five practices: terraces, animal waste storage, vegetative strips, waterways, and conservation tillage. Expert judgements on the subject were elicited from 300 conservation district and local SCS personnel across the nation. In addition 123 practices in North Carolina, Pennsylvania and Ohio, with ages ranging from five to fifty years, were assessed in the field.

In general, there is a striking disparity between potential BMP longevity and the actual lifespan of practices. This highlights the significance of O&M activities in maximizing returns on investment in NPS controls. Study results suggest that existing Soil Conservation Service life expectancies may be too conservative and that many practices can last indefinitely if properly maintained. In particular, vegetative strips typically remain effective far beyond the five year SCS estimated life spans. Similarly, even though it is often classified as an annual practice, the vast majority of local experts did not put an upper bound on the potential longevity of conservation tillage. Despite the substantially higher price, no meaningful difference in the long term effectiveness of concrete, as opposed to earthen animal waste lagoons was detected. Both appear to effectively store wastes for periods upward of twenty years. Grassed waterways may be an exception to this pattern, as site-visits and respondents revealed longevity to be somewhat lower than the 15 year SCS life-span.

The O&M activities required by different BMPs varies among practices. For vegetative practices, particularly waterways, the most important ones are passive "precautionary measures" (i.e.,caution with farm equipment and herbicides) which do not require additional spending. Similarly, both human and environmental factors affect different BMP's longevity. In some cases operators' education and environmental attitudes are viewed as having the greatest influence on a BMP's lifespan. These can be affected by through educational initiatives. In other instances, especially for structural BMPs, economic prosperity may be the most important factor, requiring a different policy response. In general, BMP longevity should play a key role in the decisions of both regulatory and nonregulatory nonpoint source policy makers prior to promotion of a particular control strategy. Operation and maintenance activities hold the key to long term water quality improvement and should increasingly become central objectives of nonpoint programs.

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I. Introduction

Significance

The Clean Water Act and its 1987 amendments call on states to design Management Programs which facilitate installation of Best Management Practices (BMPs) to control nonpoint source (NPS) water pollution. The growing recognition during the 1970s and 80s that agricultural runoff is the largest component of NPS pollution nationwide prompted increased public and private expenditures for research and management in this area. Agricultural engineers and technicians developed and documented a broad menu of structural and non-structural practices to control agricultural runoff.

Recently, interest in the life-spans of these practices has grown. While considerable data exist regarding the performance of BMPs under a variety of conditions, technical studies do not consider the performance of these practices after they have been in use for several years. Most erosion control and water quality programs in agriculture require that practices installed on private lands through public funding be maintained for specific periods of time. The Soil Conservation Service also directs state conservationists to establish life expectancies for their conservation practices. Yet, these expectations have largely been based on best available estimates from experience rather than systematic assessments. In general, little or no documentation or data exist to support these figures. The paucity of research in this area leaves water quality planners (as well as soil conservation officials) without crucial information in their attempts to design optimal long term management strategies which utilize the most effective BMPs at the least possible cost.

The ramifications of this deficiency in the current state of knowledge are potentially severe. For example, it is possible that a given management practice, proven effective in the short run, is systematically encouraged, when it actually deteriorates rapidly and has little long-term impact on water quality. Moreover, certain practices may be bypassed unwisely, when their steady performance over time actually makes them a more attractive option. Certainly, reliance on purely impressionistic information can lead to incomplete assessments of BMP cost-effectiveness as well as imprecise long term modeling and planning.

The U.S. Environmental Protection Agency in its ongoing efforts to improve the technical basis for NPS management perceived a need for research initiatives that consider BMP longevity. Three offices collaborated in designing and guiding the present study: the Chesapeake Bay Liaison Office, the Office of Program Policy and Evaluation and the Office of Water.

The primary goal of this pilot analysis is to consider the relative effectiveness of Best Management Practices (BMP) for control of agricultural nonpoint source pollution after they have been in use for some time. In addition, the study:

1) identifies and describes time associated factors which affect BMP effectiveness;

2) evaluates operation and maintenance (O&M) activities that can extend the lifetime of BMPs;

3) develops a methodology for qualitatively assessing BMP long-term effectiveness in the field.

Increased understanding about BMP longevity can be useful in a variety of programmatic contexts. BMPs promoted through technical assistance, cost-sharing, tax incentives and regulation should reflect long term environmental returns. An understanding of factors affecting longevity can offer direction about the type of control strategy and maintenance activities to support. These policy issues are discussed in the final section of this report. If nothing else, a more realistic expectation of the long term environmental prospects for a given NPS situation emerges from the study. EPA, in its oversight capacity, seeks to ensure that both farmers and the government maximize the water quality benefits of agricultural NPS controls. Without sufficient consideration of the extended time horizon, NPS programs may prove myopic, making the water quality gains of these programs extremely short lived.

II. Longevity

An exploration of the concept of BMP longevity or life expectancy establishes a useful context for the study results. There are a number of possible definitions for longevity (e.g., economic longevity, engineering longevity). In an internal guide, currently being developed at USDA, (Herndon, 1987) BMP life expectancy is presented as a function of three types of factors:

"Life Expectancy = Design Life Factor x Environmental Factor x Maintenance Factor

1. Design life is a term used by designers as the period of years they want a practice to serve its planned purpose.

2. Environmental Conditions such as landuse changes and water quality can affect the life expectancy of a practice.

3. Degree of Maintenance - timeliness of maintenance or lack of maintenance greatly affects life expectancy."

This conceptual model provides the definitional basis for the present inquiry. Longevity or long term BMP effectiveness is defined by how well the practice functions at present compared to how it was designed to function when installed. In other words, longevity is not diminished when a BMP is only 50% effective, if it was 50% effective from its inception. Its longevity, however is affected by "Environmental Conditions" and "Degree of Maintenance." For the most part, these are areas that a farm operator can influence. Hence, there is a gap between potential longevity, where environmental conditions and maintenance are optimal, and actual longevity, which reflect the more typical conditions under which BMPs operate.

III. Methodology and Study Design

The study draws its conclusions from three sources:
1) An eleven state survey eliciting expert judgements from SCS and Conservation Districts;
2) On-site evaluations in three states of 120 BMPs installed prior to 1985; and
3) Anecdotal and empirical information from discussions, observations and available literature.

The methods used in the first two, quantitative, research efforts are briefly described.

Survey of Conservation District Personnel

Environmental regulations often must be made when there is considerable uncertainty about the effectiveness of control strategies. Frequently, it is either impractical or impossible to empirically assess all possible conditions under which pollution controls must operate. The use of expert systems has become an important tool in supplementing and extending existing knowledge to situations for which no empirical validation is available. If expert judgement is properly elicited it can provide relatively quick and inexpensive information to substantiate decisions until estimates can be updated by additional empirical studies.

Conservation Districts are increasingly involved in water quality-based cost-sharing and other nonpoint source programs. A considerable amount of experience and knowledge has accrued to the District's technicians and local Soil Conservation Service personnel, who have had the opportunity to watch the performance of BMPs over an extended period. The study attempts to tap this expertise and compare it to existing longevity estimates.

A questionnaire was designed (Appendix 1) and mailed to Conservation Districts in 11 States. States were stratified so that different regions of the country would be included. Three eastern states, three western states, four midwestern states and one state from the south were selected on the basis of established local involvement in agricultural controls for water quality protection. No more than fifty districts were sent questionnaires in any given state. Table 1 indicates the number of questionnaires sent to each state and the rate of response.

Table 1. Sample Frame and Response Rate--11 State Survey of Conservation Districts

State	Total # of Districts	Responses Elicited	Number of Response	Post Oct. 1 Responses*	Response Rate
Georgia	40	40	16		40%
Idaho	51	49	22	4	53%
Iowa	100	50	40	1	82%
Minnesota	91	50	36	1	74%
Nebraska	23	23	17		73%
Oklahoma	100	50	36	2	76%
Oregon	46	46	14	1	32%
Pennsylvania	66	50	35	1	72%
Virginia	51	46	27	1	60%
Washington	48	47	24		51%
Wisconsin	71	49	33		67%
Total	687	500	300	11	62.2

*Survey results were entered and anlyzed at this point. The comments of late responses are considerred in the report, but their questionnaire results are not. In addition 5 districts responded, but did not complete the questionnaire due to inadequate technical expertise.

The questionnaire elicited both qualitative and quantitative judgements about BMP performance over time. Directions in the cover letter did not specify whether the respondent should be an SCS or district employee, but rather asked that the individual with the most field experience participate in the study. It also encouraged consultation between local technicians within the district.

Matrixes, assessing the long term effectiveness of a variety of BMPs were compiled from the responses of these field experts. Other questions considered environmental and human factors that affect specific BMPs' lifespan and also rated the relative contribution of specific operation and maintenance activities to extending BMP longevity. The study enjoyed an extremely high response rate (i.e., 62.2%) and required no followup notification.

BMP site-visits and Evaluation

Site visits to randomly selected farmers whose Best Management Practices are at least five years old offers a representative snap shot of BMP performance and longevity. Farm operations were randomly selected from an existing data base (Rosenthal, 1989) of eight counties in North Carolina and Pennsylvania, and stratified according to type of practices. In Ohio, site visits were made on the basis of recommendations from local district personnel. The tremendous variance in BMP effectiveness levels within each county suggests that the potential for selection bias is limited. Five practices were evaluated: terraces/diversions, grassed waterways, animal waste retention basins, conservation tillage, and "vegetative strips." The latter BMP generically includes both field borders as well as contour and field strips. Table 2 indicates the number of observations taken for each practice. A total of eleven observations were eliminated because information was unavailable to complete the observation and assign effectiveness ranks, or because the practice was fundamentally different than typical BMPs of this type.

Table 2. BMPs Installed before 1984: Number of Field Observations

BMP	SCS Number	Number of Observations	Usable Number	Age Range
Terraces/ Diversions	600/362	21	21	1935-83
An. Waste Storage	425/313	28	23	1953-83
Vegetative Strips	585/586	22	17	1950-83
Grassed Waterways	412	33	33	1950-83
Conservation Tillage	329	19	18	1960-84
Total:		123	112	1935-84

While most field technicians can distinguish a BMP that is in good condition from one that is not, such distinctions are typically subjective in nature. The study's greatest methodological challenge was development of an objective measurement system. The system was to rate BMP effectiveness on some basis other than pure water quality parameters, which are costly and require ideal rainfall conditions as well as longitudinal precipitation and baseline data.

Urban developed a ranking system to assess the condition of management practices as a surrogate to traditional water quality or soil tolerance criteria. A list of physical characteristics for each BMP which affect their effectiveness was generated in consultation with staff members from USDA-SCS and U.S. EPA. A worksheet for each practice evaluated was prepared to record the findings. It included the specific physical characteristics of the BMP along with general data, including year of installation, cropping system, soil type, percent slope, slope length, soil type, O&M and O&M needed. Whether the BMP was installed according to a conservation plan and/or received cost-share funds was also noted. Some refinements were made in the worksheets during the field work phase, but the forms remained essentially unchanged.

A qualitative evaluation system was utilized to generate observations. Each characteristic was rated either good fair or poor using a numeric scale of 3,2 and 1 respectively. Polaroid photos were taken to document the conditions for each characteristic, enhancing consistency over time and between states. Scores for individual characteristics were aggregated to form a single outcome for each observation. From the composite score a level of effectiveness is inferred. This effectiveness rank can range from 0 to 1.0, according to the composite score's relative proportion to a perfect rating, when all characteristics are graded at 3. The division into three categories (good- .80-1.0, moderate, .60-,80 and poor ,.60) is fairly arbitrary, but helps make results more readily interpretable Appendix 2 offers copies of the worksheets and a more in depth description of the Urban Longevity Scale.

Observations from randomly selected operations were supplemented by visits to farms which Conservation District personnel recommended due to the age of particular practices. Because the aggregate scores for these farms were not unusually high, it is unlikely that these observations introduce a bias into the study results. Other precautions were taken to reduce biases during the study. To prevent a single farm's undue influence on the outcome, the protocol established that a maximum of five

observations could be taken from an individual farm operator. In a given operation, no more than two observations of a single type of practice were taken, and only if their installations were separate by a two year interval.

For both the survey and observed measurements, data was entered in the Lotus 123 program and analysis was conducted using SAS statistical software. Quality control measures included standard 10% two-person checking and reentry procedures for accuracy so that data entry is not a source of error.

IV. Study Results

The following section offers a practice-by-practice description of the study results. This includes both the quantitative data from the survey and site-visits as well as general phenomena reported by respondents and observed in the field. Present SCS estimates are contrasted with the data accrued during the study. In general both components of the study confirmed the great disparity between the potential longevity of practices and the actual amount of time they remain effective. This highlights the importance of O&M in any nonpoint control scheme.

Terraces and Diversions

Terraces appear to have the potential to last indefinitely with proper operation and maintenance. As indicated in figure 1, almost half of respondents believed that this practice has the potential to last longer than twenty five years, the highest category. In contrast, actual longevity was estimated to be considerably lower, with approximately 50% of respondents rating actual life spans of ten years or less. The SCS estimated life-expectancy for terraces of twenty years appears justified as 80% of respondents confirmed this as the minimal potential longevity.

Figure 2 indicates the perceived impact of different factors on terrace longevity. The most important factor appears to be whether or not the operator owns the land under cultivation or not. Accordingly, tenants are less likely to provide the ongoing maintenance necessary for preservation of terraces. Two other human factors deemed important are the economic prosperity of an operation and the level of an operator's education. The most important physical characteristic affecting terrace longevity is the slope of the land. Soil type is relatively less important.

Figure 1

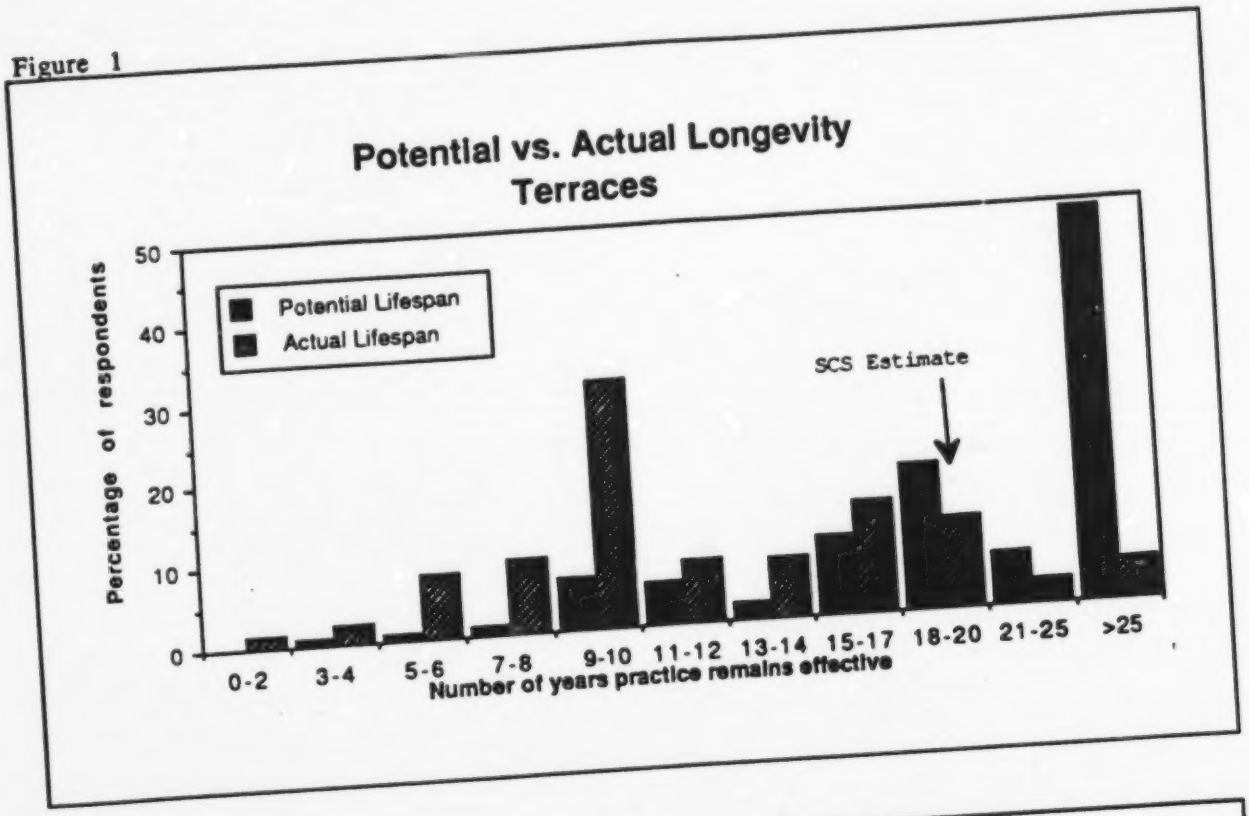
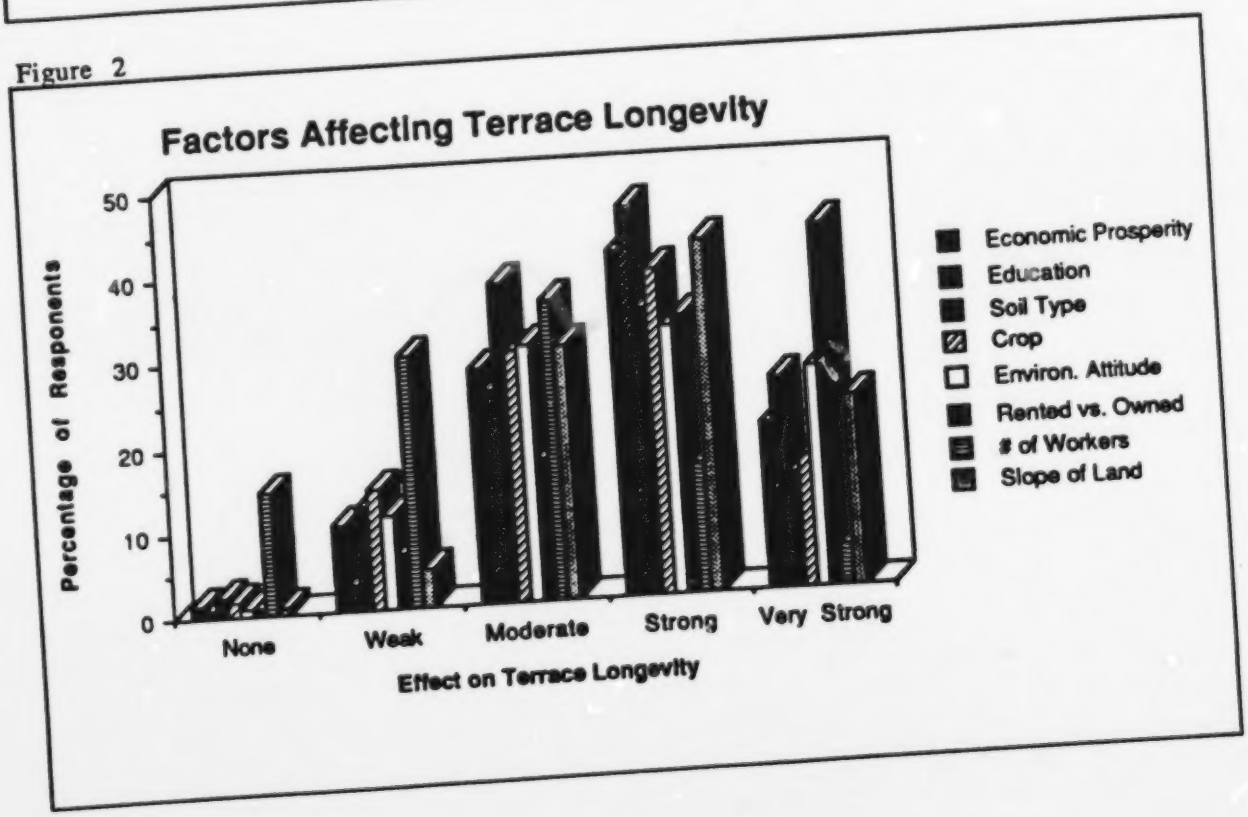


Figure 2



Results from the survey suggest that the longevity of diversions are extremely comparable to terraces. While perceived life-expectancies are somewhat smaller, (both potential and actual), the largest group of respondents (some 40%) believe that diversions can last more than twenty years. The SCS established life-expectancy for diversions is 15 years, 5 years less than terraces. Insofar as actual longevity is deemed considerably lower than potential, with 10-12 years being the most commonly selected category, the data support the SCS estimate. (See figure 3). Not surprisingly, the factors affecting diversion longevity are identical to terraces. "Rented versus owned" is considered to be the most important factor associated with longevity, with education and "slope of land" following as important factors.

Figure 3

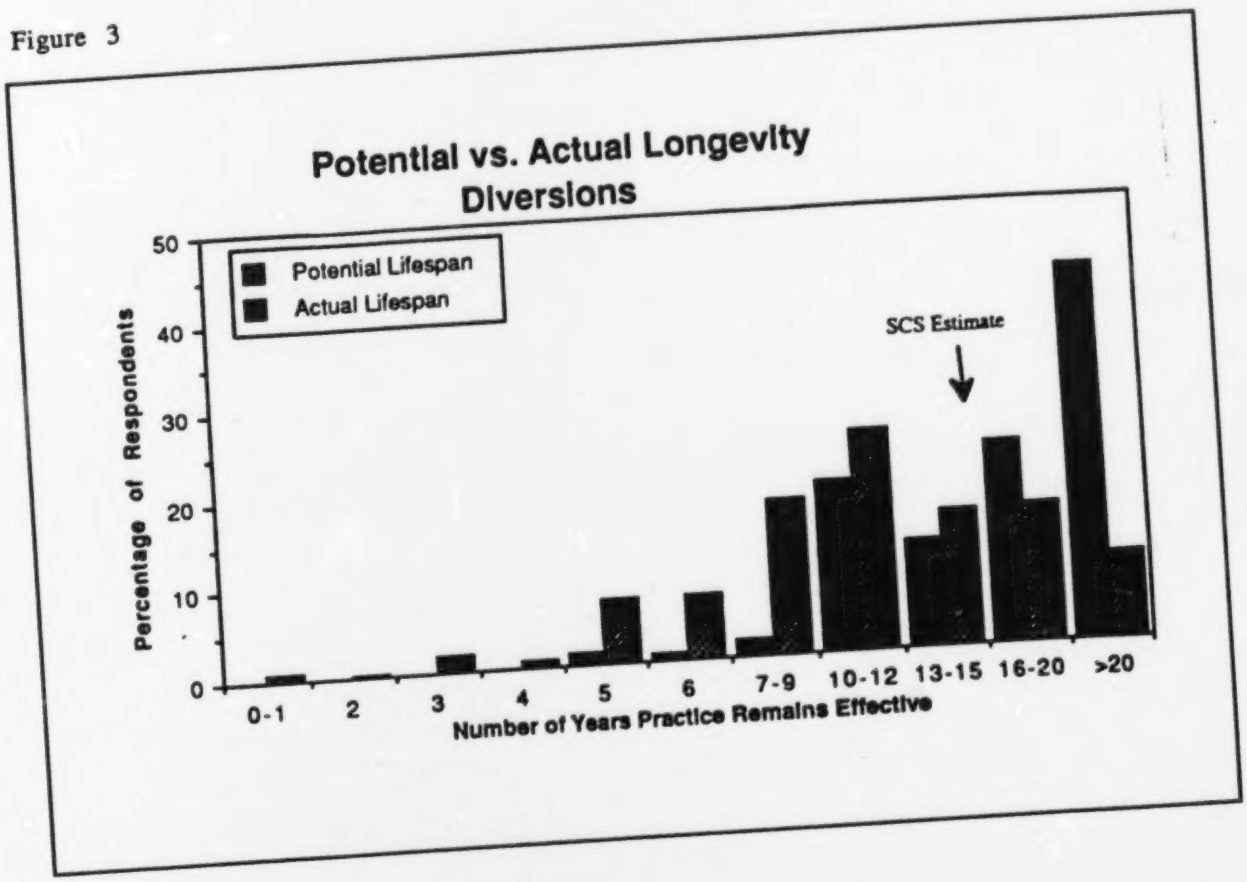


Figure 4

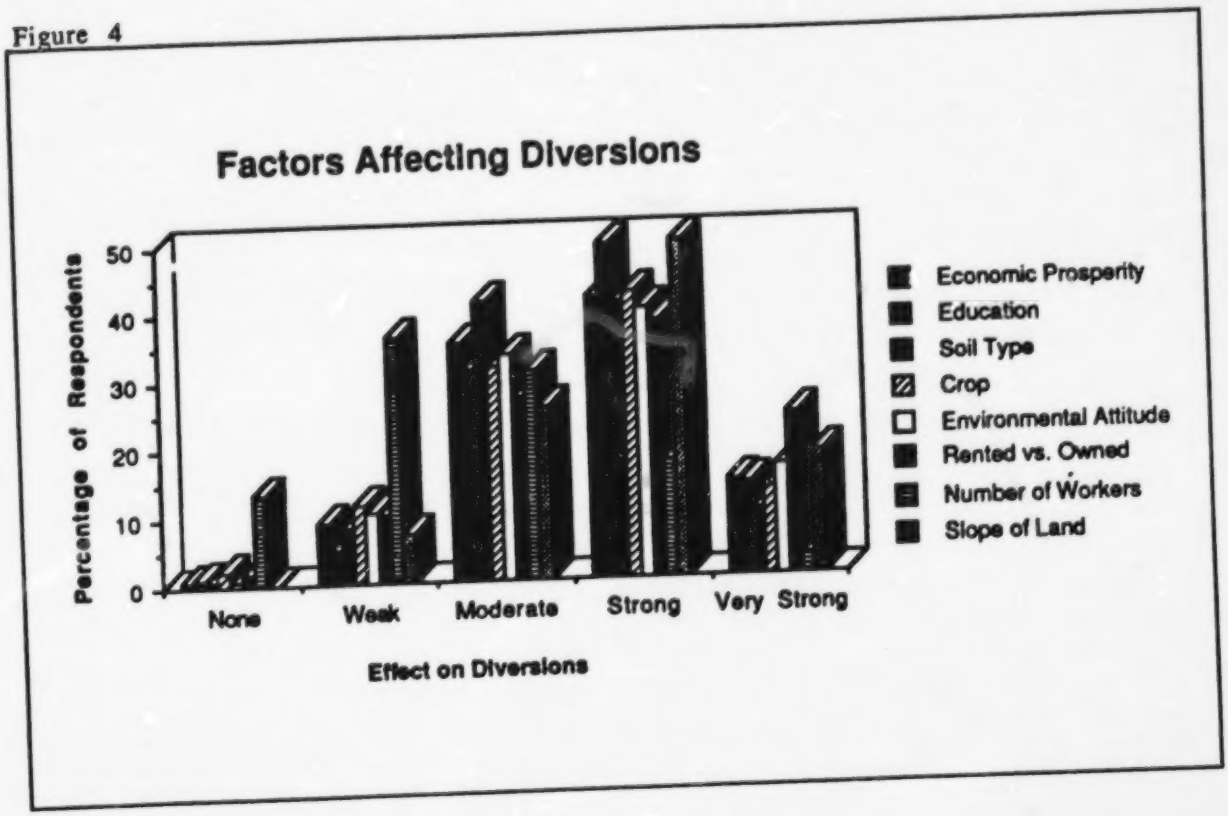
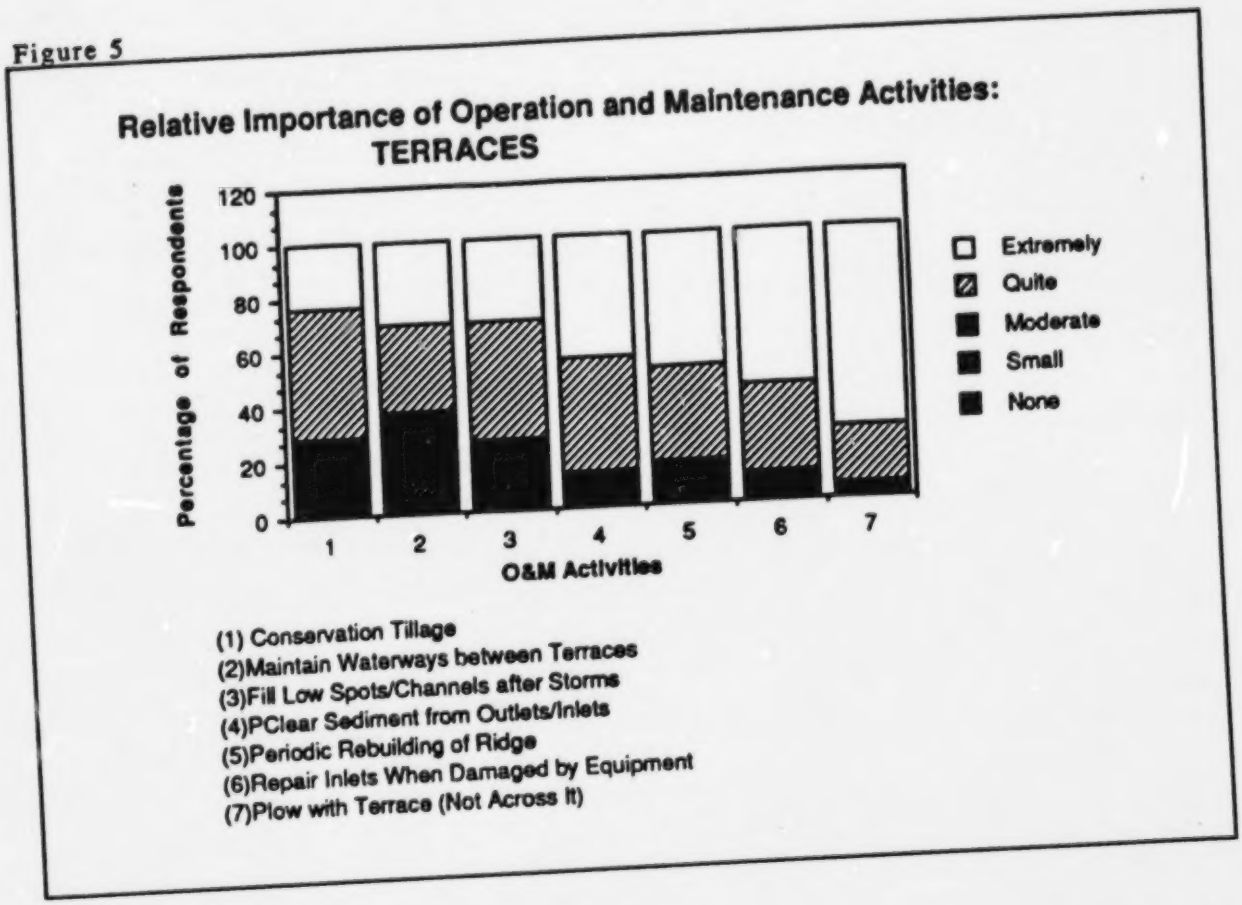


Figure 5 depicts the relative importance of different O&M activities in increasing order as perceived by the local experts. All of the seven activities appear to contribute to terrace longevity, yet it is possible to make certain distinctions. Accordingly plowing with the terrace (and not across it) was deemed by local experts to be the most important single O&M activity for maintaining terraces. Periodic repairing of inlets when damaged by equipment, rebuilding of ridges and sediment removal from outlets are also seen as key O&M activities. Conservation tillage, while the least important of the O&M activities, is still considered quite or extremely important by 70% of respondents.

Figure 5



During site-visits, it was found that the term "terraces" was used by landowners to describe a variety of practices. These ranged from fully vegetated diversions to cropland terraces for tobacco, rebuilt on an annual basis with motor graders. In general, the current effectiveness levels of the twenty one terraces and diversions observed was very good, and confirmed the 80% of survey respondents who estimated that actual longevity was nine years or more. Of the twenty one terraces and diversions observed, 71% fell within the highest "good" category, with composite score upward of 80%. Only three systems received perfect scores. The two systems receiving the poorest ratings, were installed in 1950 and 1972 without cost-share funds. (In general, no statistical association between longevity and cost-sharing was identified).

Although as a group, diversions had higher scores than terraces, the small sample size precludes generalization. Of interest, the two oldest systems observed, a Randolph County, NC diversion system installed by the CCC in the 1930s and a Chatham County, NC terrace installed in 1940 both

fell within the highest "good" category with .83 and .80 composite scores This also confirms the optimistic potential estimations of survey respondents.

Table 3. Terraces and Diversions: Field observations

Year	Good (.80-1.0)	Fair (.60-.80)	Poor (< .60)
1980-89 (< 10 years)	4	0	0
1975-79 (10-15 years)	1	0	0
1974, 1953 (>15 years)	11	3	2

In addition to the actual scores, the following trends were notable:

* Cropland terraces, were generally not tilled, supplementing the system with field and contour strips and leaving the ridge and channel undisturbed;

* Older systems were often adjusted to allow for cross slope cultivation in field strips without "point rows;"

* All systems had been graded at some point to remove excess water;

* Extremely low berms still proved effective in reducing rilling;

* Terrace spacing rarely exceeded 90 to 110 feet; and

* Terraces used in tobacco culture posed unique problems, requiring intensive maintenance and use of heavy equipment for rebuilding.

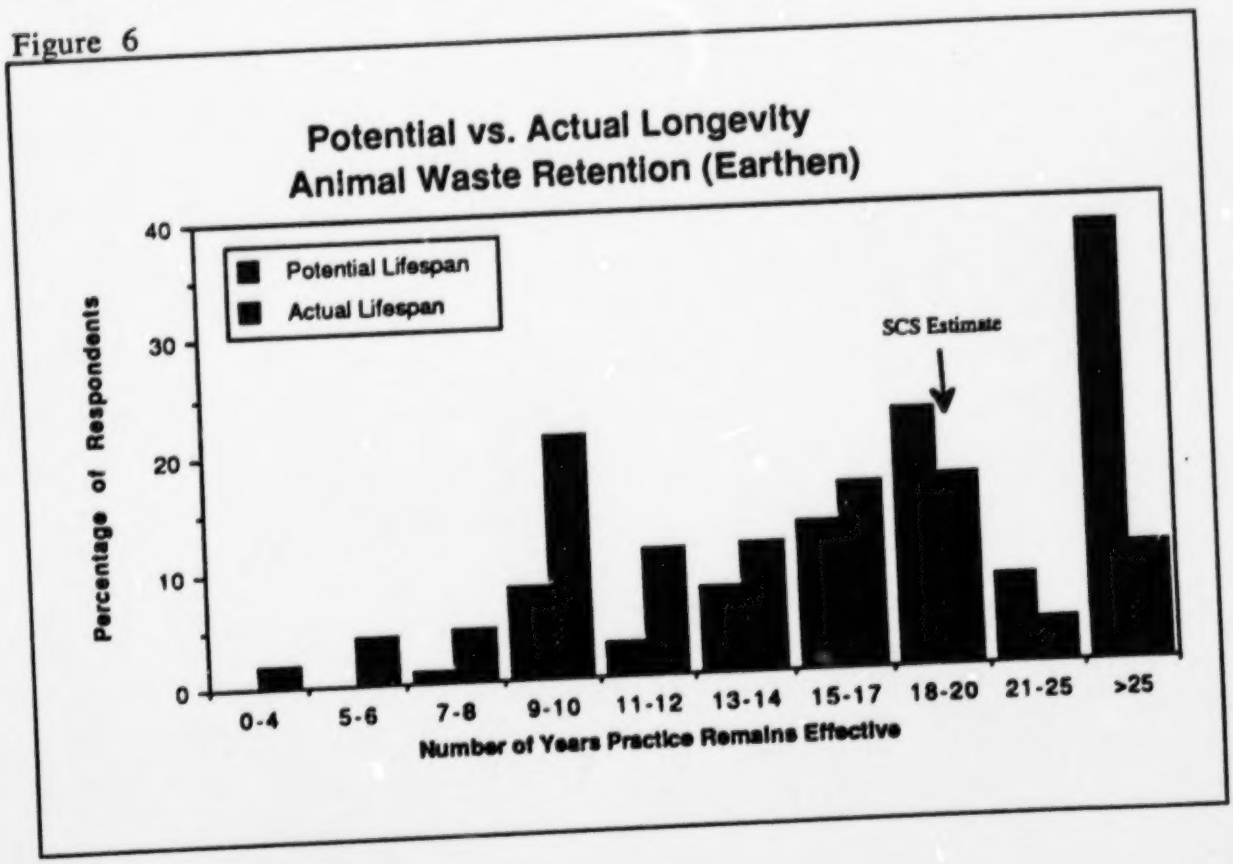
In summary, terraces appeared to be a particularly long lasting practice if maintained on a fairly routine basis. Rebuilding the ridge, although fairly common, is frequently only necessary after ten year spans if supporting practices are in place and plowing is done parallel to the berm. There is no indication that the effectiveness of the oldest practices is any less effective than when first installed suggesting that there may not be a "finite" life expectancy for a properly maintained terrace system.

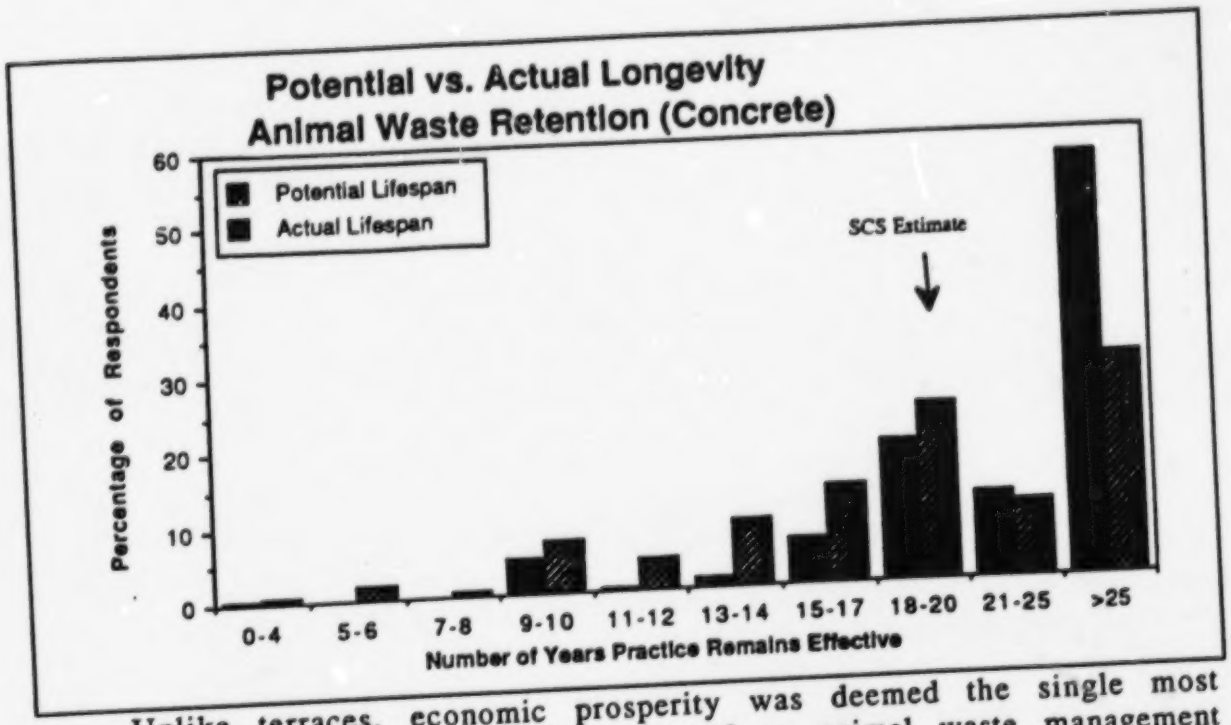
Animal Waste Management

The study considered both earthen animal waste retention facilities and concrete retention facilities. Insofar as cost-share funds have only been available for the latter fairly recently, relatively few concrete structures (installed prior to 1985) were available for field observations. Yet, these confirmed the views of the local experts which did not consider the more expensive concrete structures to be considerably more long lasting than the traditional, earthen facilities. Figure 6 presents the longevity estimates from the survey for both of these practices:

The majority of respondents did not distinguish between the two practices appraising potential longevity to be upwards of twenty five years. Actual performance of concrete waste retention facilities, however is rated to be somewhat better. The 30% of respondents who feel that earthen lagoons remain effective for ten years or less is four times greater than the 7%, who are as pessimistic about concrete facilities' prospects. Over 50% of the local experts felt the actual lifespan of concrete facilities to be 18 years or greater, while only 30% had such confidence in earthen structures. SCS estimates of 20 years, therefore, appear to be reasonable.

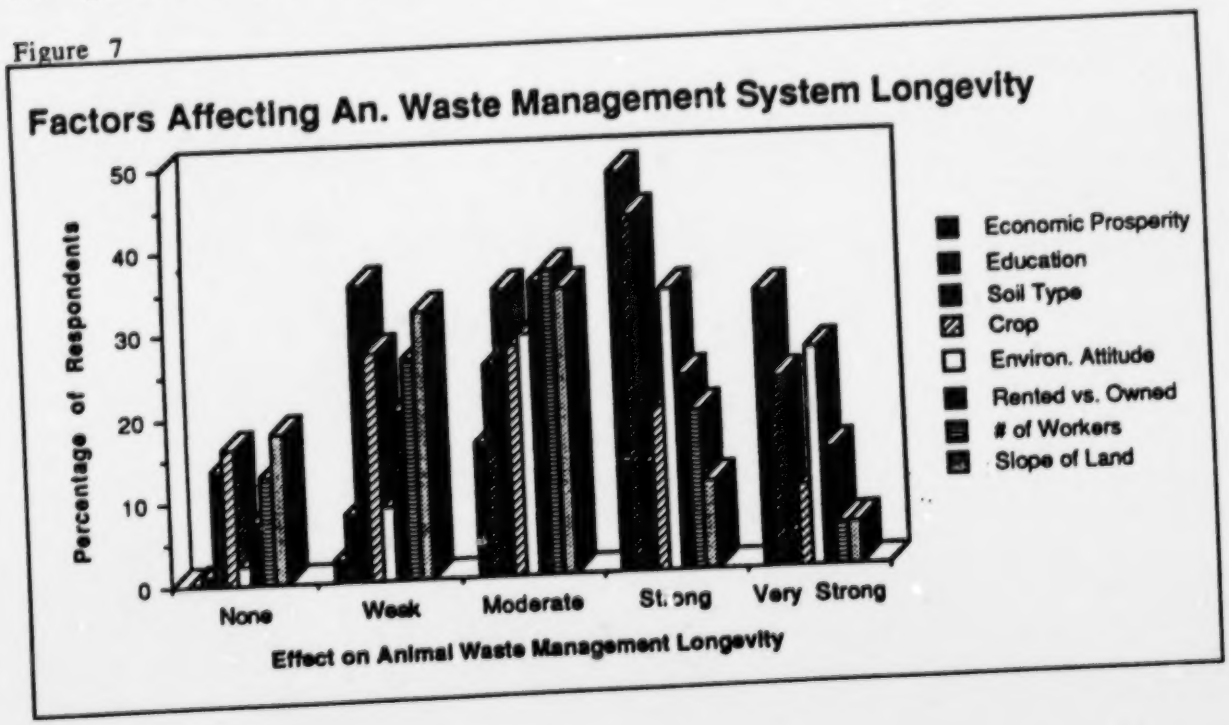
Figure 6





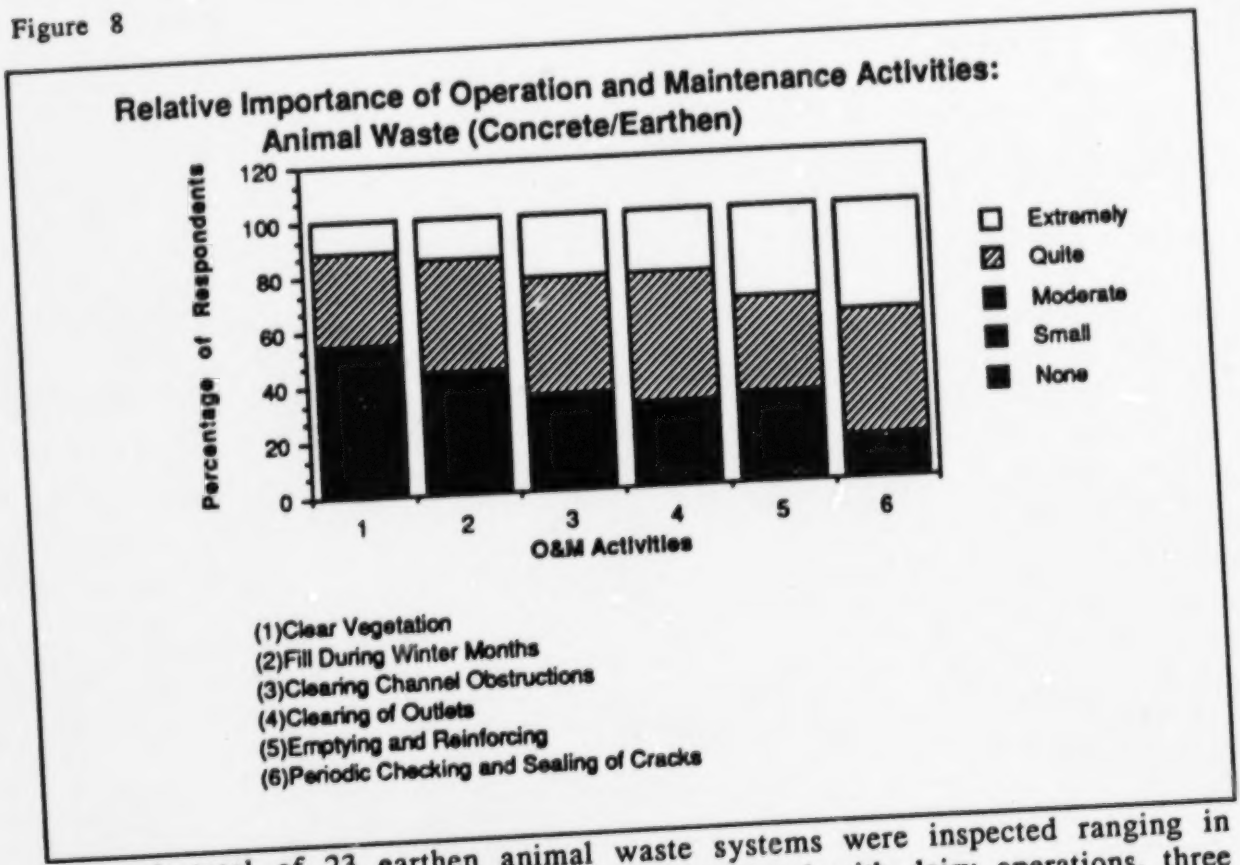
Unlike terraces, economic prosperity was deemed the single most important factor affecting the longevity of an animal waste management BMP. The second most important factor was the "environmental attitude" of the operator and his education. (See figure 7).

Figure 7



A clear hierarchy of O&M activities emerged from the survey results. Accordingly, periodic checking and sealing of cracks was considered to be the most important maintenance activity, with 80% of respondents assessing it as either extremely or quite important. This was followed by emptying and reinforcing, as well as clearing of outlets and channel obstructions. Filling during the winter months and clearing vegetation the banks were the two least important activities with less than 50% viewing them as quite or extremely important. Figure 8 depicts the perceived importance of different O&M activities in animal waste management systems.

Figure 8



A total of 23 earthen animal waste systems were inspected ranging in age from 36 to 6 years. While mostly associated with dairy operations, three hogs and one chicken lagoon were evaluated. The effectiveness levels found among the earthen systems was superb, with all but one falling in the highest category, showing overall effectiveness scores greater than .80. The one system ranked to be only moderately effective had two major deficiencies: inadequate capacity and poor surface water controls.

With the exception of one North Carolina lagoon installed in 1953, the systems were all built during the 1970s or early 1980s. Accordingly, most of the practices are still many years away from reaching their SCS design life expectancies. Nevertheless, with one exception there were no signs of any discernible deterioration which might hinder effectiveness in the foreseeable future. (The exception, a Bucks County, PA lagoon, operates well at present, but the numerous trees on the fill foster extensive groundhog burrowing which portends serious problems). Ironically the oldest, 36 year old, lagoon was the only BMP in this group to receive a perfect score of 1.0. Table 4 presents a matrix of the observations:

Table 4. Animal Waste Retention Basins: Field observations

Year	Good (.80-1.0)	Fair (.60-.80)	Poor (< .60)
1980-89 (< 10 years)	14	1	0
1975-79 (10-15 years)	8	0	0
1974, 1953 (>15 years)	2	0	0

In addition, four animal waste systems, built entirely or partially from concrete were assessed. This constitutes an inadequate sample size for statistical inferences. Nevertheless, it is striking that two of these systems had scores of .55 and .33 respectively, falling within the "poor" or ineffective categories. Both practices were built in 1978 and 1979, utilizing concrete floor and boards as walls to contain the manure. Inadequate capacity (and emptying schedules), seepage slumping and deposition were among the major problems discerned.

The visits revealed the following points:

* All landowners were completely satisfied with the BMP. In retrospect, few would make modifications if they were to build them again;

* There was a consensus among owners that rounding the corners of a lagoon makes agitation, prior to emptying, a good deal easier.

* "Buildup" was only deemed a problem when sand or lime was used as bedding;

* In some dairies, thick crusts with grass posed a problem, clogging the pumps;

* Maintaining an adequate bacterial base was a problem in some hog and chicken facilities. As a result, several "seeded" their lagoon with sewage sludge;

* Of the many lagoons designed for twice-a-year emptying, many would prefer at least a seven month capacity, that would offer greater flexibility;

* Many operators related cases where equipment or livestock were lost in the lagoons. Solutions include installation of "tie down anchors" and fencing;

* Several operators added water from roofs or milkhouses to aid in agitation. Rarely was excessive water supply a problem; and

* Although common, concrete ramps or piers are used infrequently and in some cases appeared to hinder operators during emptying.

In conclusion, from the study results it is difficult to associate clear advantages with a concrete retention system over an earthen one. Both appear to last very long and operate well with a minimum of maintenance activity. Design improvements might include rounding corners, increasing outside slope, fencing a larger area, installation of safety anchors for pumps, and improved provisions for control of water inflow. Ramps and piers are often superfluous. The only important maintenance activity which emerges from the site-visits are occasional clearing of woody vegetation and elimination of burrowing animals. Hence, while animal waste retention facilities, like most structural BMPs may require extensive capital up front, they are likely to be an excellent long-term investments.

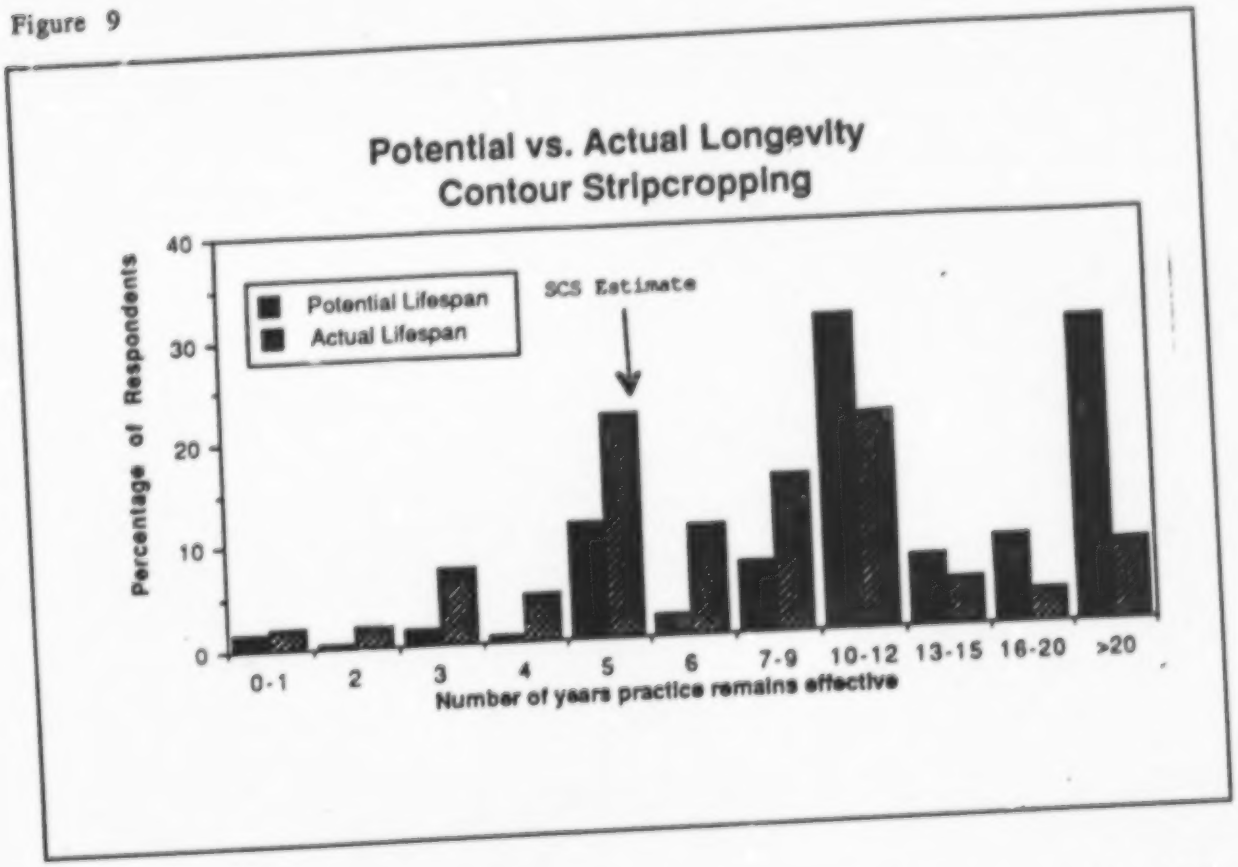
Vegetative Strips

There are several different types of "strip cropping" which are used in water management systems. These include contour strips, field strips and field borders. To reduce confusion, respondents were questioned about only one form of strips "contour strips." Nevertheless, presumably, the results have broader implications for a variety of vegetative practices.

Contour strips were one of the BMPs where respondents life expectancy estimates diverged substantially from that of the Soil Conservation Service. Accordingly, although SCS sets contour strips longevity

at 5 years, greater than 80% of respondents report that potential lifespan is far greater. Some 30% believe that if properly maintained contour strips can last more than 20 years. Actual estimates are also higher than SCS life expectancy. Over 65% of local experts estimate that the actual life spans of contour strips are greater than 5 years. Figure 9 presents perceived versus actual life expectancies for contour strip cropping.

Figure 9



Respondents indicate that most of the "factors" they asked to consider have a "strong" or very strong" effect on contour strips' longevity. Only "number of workers," a surrogate variable for corporate farming, was deemed relatively unimportant. Figure 10 presents the bar graph for these factors:

Figure 10

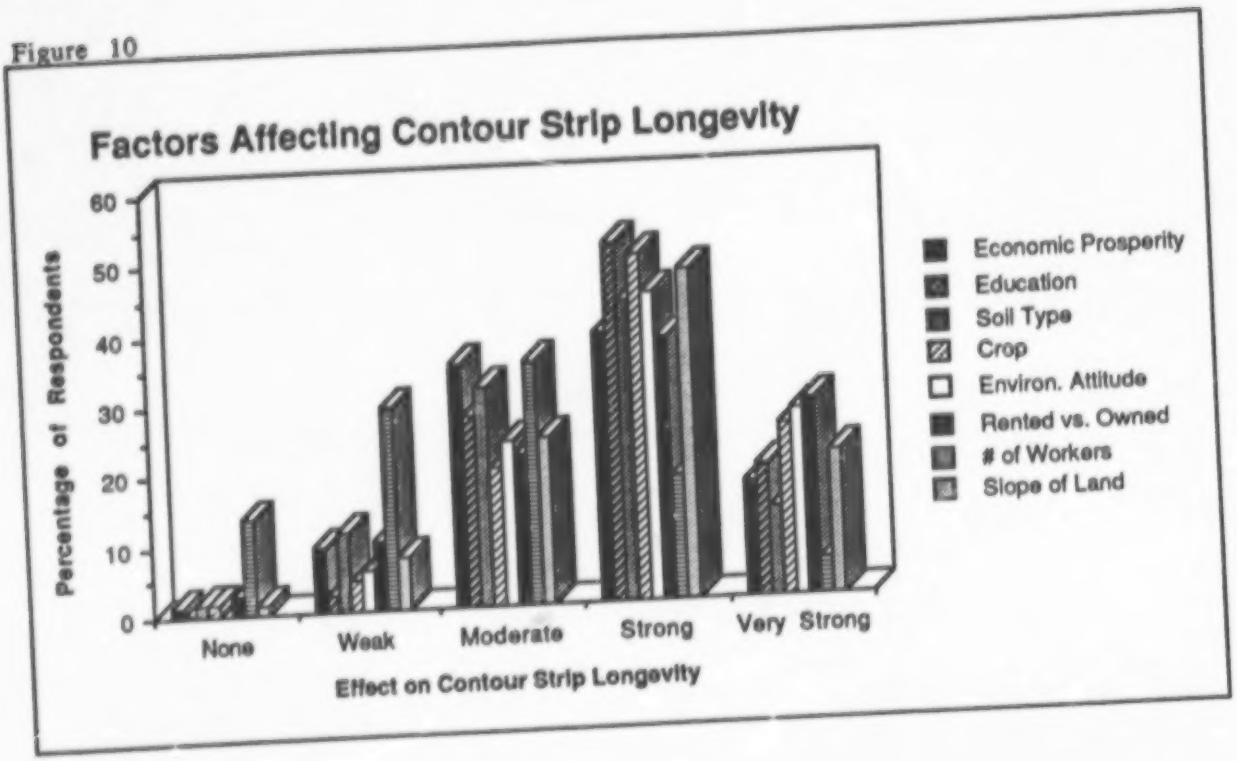
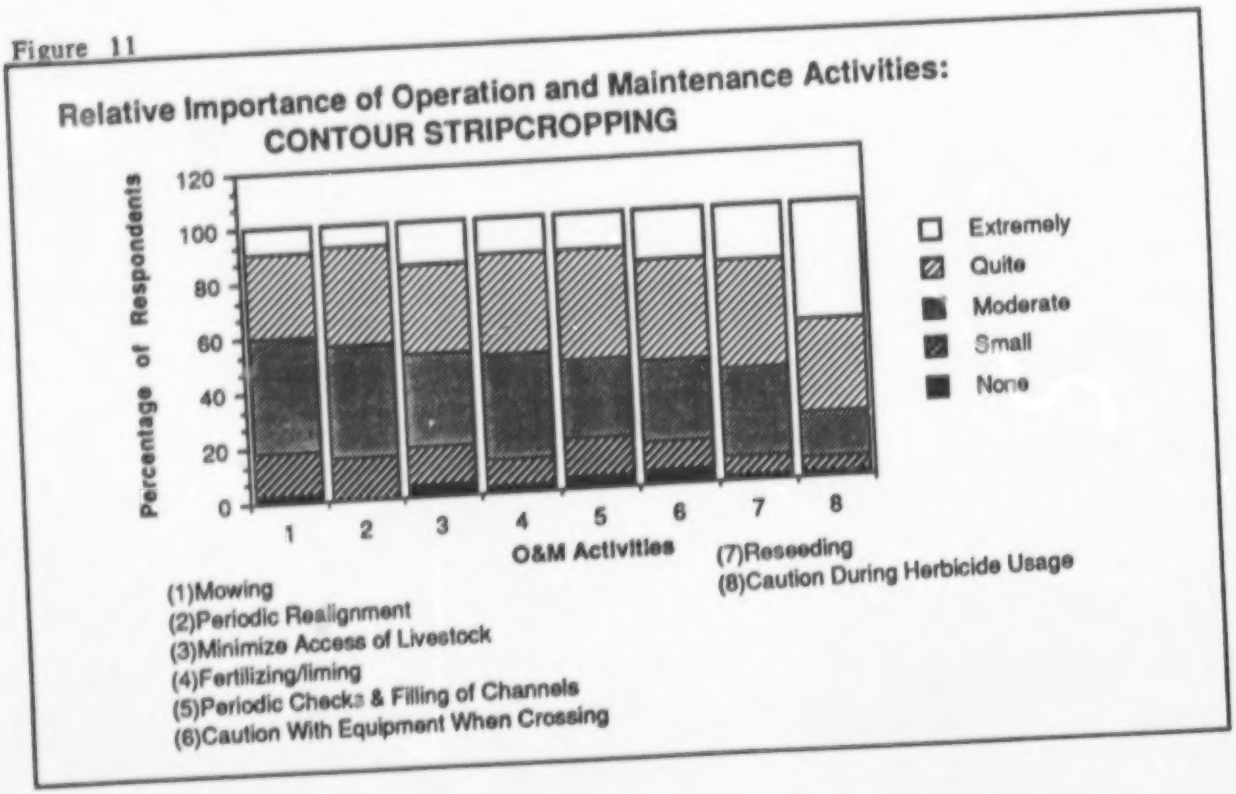


Figure 11



Experts clearly feel that some O&M activities are more important than others. Caution during herbicide usage in particular was considered quite or extremely important by roughly 80% of respondents. Reseeding and caution with equipment were considered next in relative importance. In contrast, more than 60% of respondents felt that mowing and realignment were only of moderate or small importance for the practice's longevity. Figure 11 presents the results of the O&M query for contour strips.

As mentioned, on-site visits considered a broader group of "vegetative strips." Twenty two practices were evaluated, ranging from 39 to 6 years of age. This number narrows to 17 when field borders and practices where only one strip was assessed are removed from the sample. (Field strips across the slope accounted for the largest number of observations). In general the contour and filter strip systems appeared to be in excellent condition, performing well many years following installation. When the practices are divided according to year of installation in table 5, the group in best condition is the oldest one, installed over 20 years ago. This suggests that O&M is more important than any inherent engineering life for the practice. A slight benching could be detected among the lower sides of older contour strips which could sometimes reach as high as a foot. Soil creep and tillage provided the most obvious explanations for this phenomenon.

Of the strips examined, 21% were deemed moderately effective and only 1 observation (5%) fell below this into the "poor" category with an overall score of .44. The remaining 73% of the observed filter strips fell in the highest category. This BMP also had the highest number of "perfect scores." The only practice in clearly poor condition was installed in 1972 and today suffers from rilling, deposition and eroded vegetative cover. These observations tend to confirm the optimistic numerical estimates of respondents relative to the more conservative official SCS life-expectancies.

Table 5. Vegetative Strips: Field observations

Year	Good (.80-1.0)	Fair (.60-.80)	Poor (< .60)
1980-83 (7-10 years)	1	0	0
1975-79 (10-15 years)	2	0	1
1970-74 (15-20 years)	4	0	0
1950-1969 (>20 years)	9	0	0

Other phenomena associated with this practice observed in the field include:

* Once a meadow strip is established it often remains in use until yields decrease or annual grass and weeds take over. Hence strips remain in a continuous crop for up to six years;

* It is common for two strips to be combined into a single crop, often resulting in excessively long slopes and soil movement within rowcrop strips;

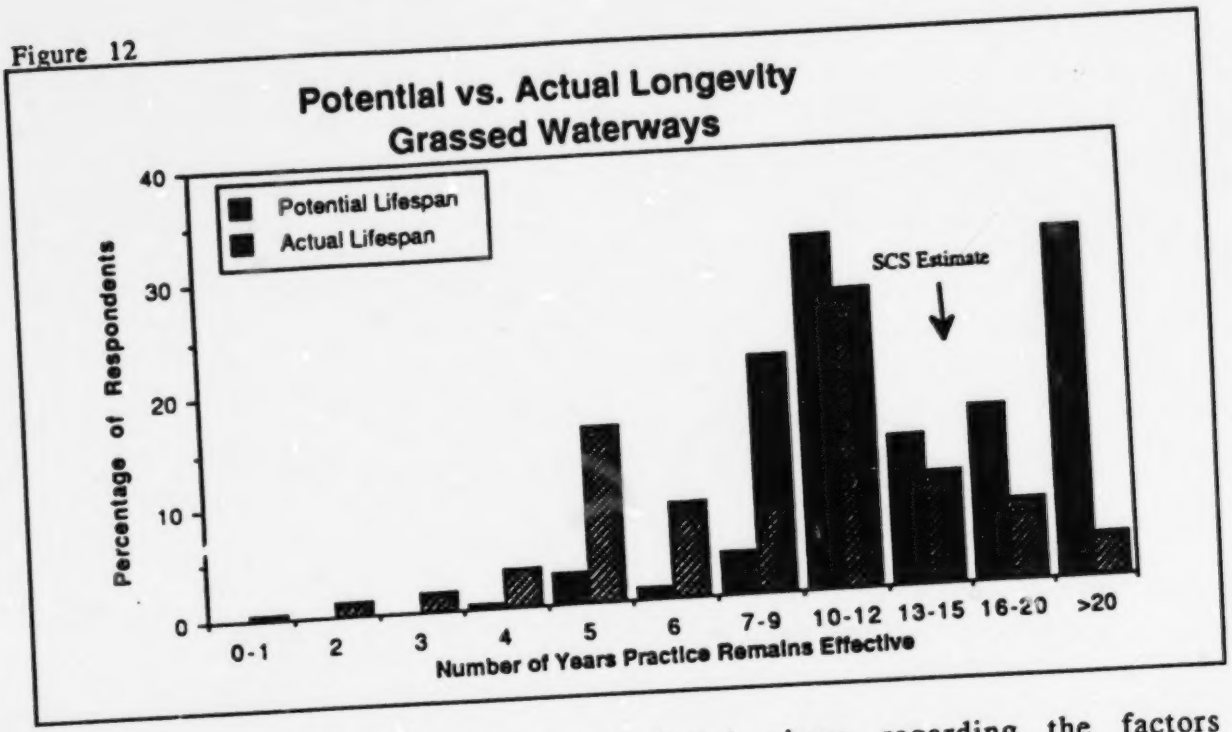
* Although landowners recognize the deficiencies inherent to combining strips, they feel compelled by their need for higher yields or the failure of a meadow stand;

In conclusion, vegetative strips appear to be more long lasting than previously expected. Field inspections support this view, yet the observations suffer to some extent from methodological inadequacies. The ultimate criteria for field borders and vegetative strips should be whether they effectively prevent sediment from reaching the area needing protection. As such, they can only be evaluated as a system. This might be done by averaging the scores of a cultivated strip and a meadow strip. Beyond periodic reseeding, it appears that little or no maintenance is required, to preserve vegetative strips. The most important O&M activities are essentially passive and "precautionary" in nature: avoiding herbicide spills and damage while crossing strips with equipment. Ineffectiveness may also result from poor design, or combining strips so that adjacent strips are not sufficiently narrow to reduce runoff velocities to non-erosive levels.

Grassed Waterways

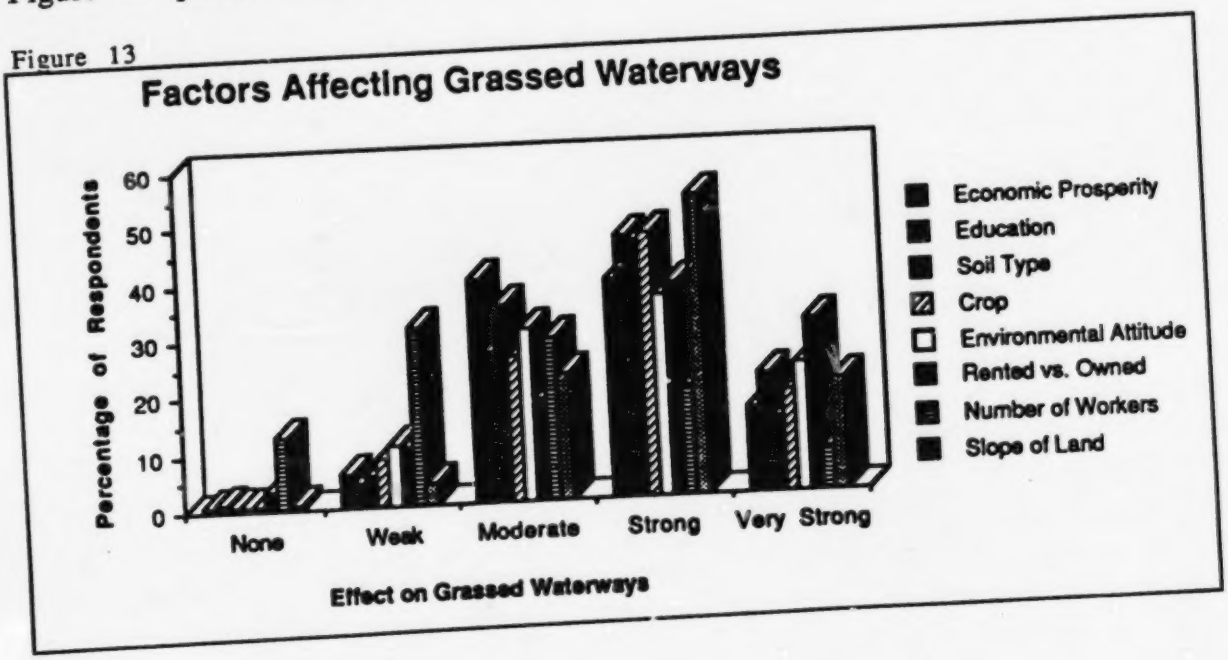
Grassed waterways is the one BMP where the estimated longevity by respondents is more conservative than that of the Soil Conservation Service estimate of 15 years. Over 50% of respondents estimated that waterway longevity is 15 years or less, with over 30% estimating potential as no greater than 12 years. In practice, the disparity is even greater; less than 20% estimate actual longevity to reach 15 years or greater. Figure 12 presents these results.

Figure 12



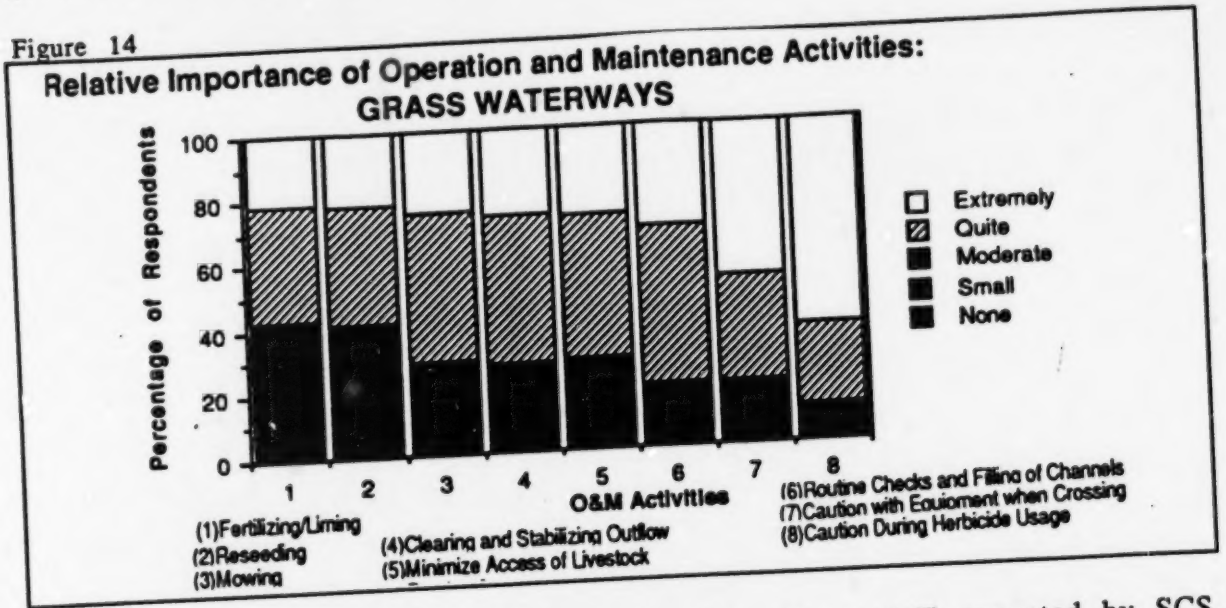
As might be expected, respondents' views regarding the factors affecting grassed waterways effectiveness are essentially identical to contour strips with one exception: Slope of land is considered to have a slightly greater influence on waterway effectiveness than that of contour strips. Figure 13 presents these results.

Figure 13



Similarly O&M for these two "vegetative practices are similar. Reseeding, however, is not considered very important for upkeep of waterways. Nevertheless, the so called "precautionary" practices (caution with herbicides and farm equipment) are by far perceived to be the most important for their preservation. (See Figure 14).

Figure 14



Field observations confirm both the higher "potential" expected by SCS and the lower expectation of actual longevity reflected in the survey results. Four of the five oldest waterways found among the three states, (all operating for greater than 25 years) were rated in the most effective category. The oldest waterway in the sample, installed in 1950 with an overall score of .78 is moderately effective, 2 points shy of falling within the higher group. Notably a 1962 waterway in Northampton County, Pennsylvania indicates potential longevity. It received one of two perfect scores, appearing as effective 27 years after installation as when it was first built.

Yet, only 55% of the 33 observed practices were rated in "good condition." This is far lower than any other BMP evaluated. The four waterways (12%) rated in poor condition are on erosive North Carolina tobacco land. Observations in the field confirm the importance of precautionary O&M activities. The ostensible reason behind their ineffectiveness is the absence of cover and crossing damage from constant usage as roads for heavy farm equipment. Poor ground cover was also traceable to herbicide spills fairly frequently. Eleven waterways (33%)

were rated only moderately effective. The most common failure involved the development of a narrow rill (1 foot wide, and 1 to 3 feet deep) in the channel bottom due to erosive velocities.

Table 6. Grassed Waterways: Field observations

Year	Good (.80-1.0)	Fair (.60-.80)	Poor (< .60)
1980-89 (< 10 years)	8	4	1
1975-79 (10-15 years)	2	5	1
1974, 1953 (>15 years)	6	5	1

Some experts argue that if a waterway is doing its job, (removing suspended sediment and nutrients from the stream flow) it should destroy itself after a finite period (e.g., five years). An opposing view would argue that in such cases the cropping system is inadequate for maintaining the soil resource. While there is undoubtedly deposition in waterways after several years of usage, this rarely appears to eliminate requisite capacity. A greater threat to waterway through deposition is posed by parallel cropping systems. The plowing of headlands frequently leads to a buildup of a ridge or channel adjacent to waterways. As a result a waterway that may look very impressive is obstructed and carries little water during storm events. Waterways appeared to be most effective when they were "crossed" perpendicularly with appropriate grading. An angled crossing often led to ragged edges either from inadequate width or cutting by equipment.

The following emerged as additional aspects of waterway longevity:

* While local SCS and Conservation District Officials may consider it relatively unimportant, (third from last), mowing is by far the most common O&M activity undertaken by operators;

* Conscious efforts to fertilize waterways are relatively rare;

* Outlet failure was not a factor in waterway longevity. Often outlets were formed by rock chutes or other outlets formed from local materials;

* Subsurface drainage often proved necessary when the waterway drains an intermittent natural stream or when a waterway accepts runoff from adjacent farms, roads and seep areas.

Waterway longevity was noticeably poorer than that of other BMPs observed. It would seem that with small changes in design, however, they might last longer. Beyond perpendicular crossing, increasing width might provide a lane for transportation outside of the channel bottom. A broader grassed berm should be considered in design which might enable large equipment to manipulate without encroaching on the channel. Ironically, it appears that the "least constructed" waterway yielded the most effective practice. This may be because by leaving some top soil, a more deeply rooted sod takes hold.

Conservation Tillage

Conservation tillage differs from the previous practices described for several reasons:
(1) it is considered by SCS to be an "annual" practice;
(2) it is not a structural practice;
(3) it is a relatively recent BMP;
(3) there is minimal literature from which the potential longevity of this practice can be inferred.

Prior to presentation of the results, therefore, a brief presentation of research about long-lasting conservation tillage plots is instructive. Conservation tillage in general and no till in particular became possible during the early 1950s when herbicides became available. (Sprague, 1952. Triplett, 1970). As a result, even the oldest no till or reduced tillage systems can only be 30 years old. The Ohio State University Agricultural Research and Development Center in Wooster Ohio established two plot in which no-till corn and oats have been in continuous production since 1962 and 1963. Comparison of yields since 1963 between adjacent no till, minimum till and conventional till plots on a typic fraguidalf soil revealed that over time no till can improve yields:

"The influence of tillage on corn grain yield was significant (P=0.05). No tillage practices produced an average of 0.84 MG ha^{-1} more corn grain than did the plowed treatment over the 23 year observation period. Increased yields associated with NT on the Wooster soil is generally attributed to greater water use efficiency resulting from increased water infiltration, decreased evaporation or both. In addition the positive effect of NT on yield

on the Wooster Site may be due to a decreased erosion retention or development of favorable soil structural characteristics..." (Dick, et al. 1986) A similar controlled experiment on Mollic Ochraqualf Soil, however, produced opposite results, suggesting that no till's effect on yields may be dependent on soil type. (Dick, et al. 1986)

While it is important to establish the economic viability of extended continuous no-till, this study's primary concern involves the question of runoff. USDA's North Appalachian Experimental Watershed in Coshocton Ohio has grown no-till corn continuously in certain watersheds since 1964. Continuous monitoring suggests that no-till can maintain its effectiveness indefinitely. For example data from 1979 to 1985 suggests that only 1.5% of total precipitation left the watershed with the no-till corn as surface runoff. In contrast, runoff in the paired watershed that utilizes conventional tillage was more than ten times greater. (Edwards, et al., 1988). Table 7 is a reprint of the raw data from the study, following the effectiveness of a no-till field from its 16th to 21st year.

Table 7. Total rainfall, intense rainfall and runoff for Watersheds 191 (No till) and 123 (Conventional Tillage), 1979-1985

Year	Total precipitation	Intense rainfall*	(Ws191) No-Till Runoff	(Ws123) Conv-Till Runoff
		mm		
1979	1124	92	3.81	140.0
1980	1175	80	4.90	313.0
1981	1057	88	0.14	142.0
1982	889	137	0.00	-----
1983	1027	174	0.00	-----
1984	909	198	2.31	-----
1985	929	139	0.01	-----
Average:	1016	908	11.17	177.0

*Rain falling at intensity > 50 mm/h.

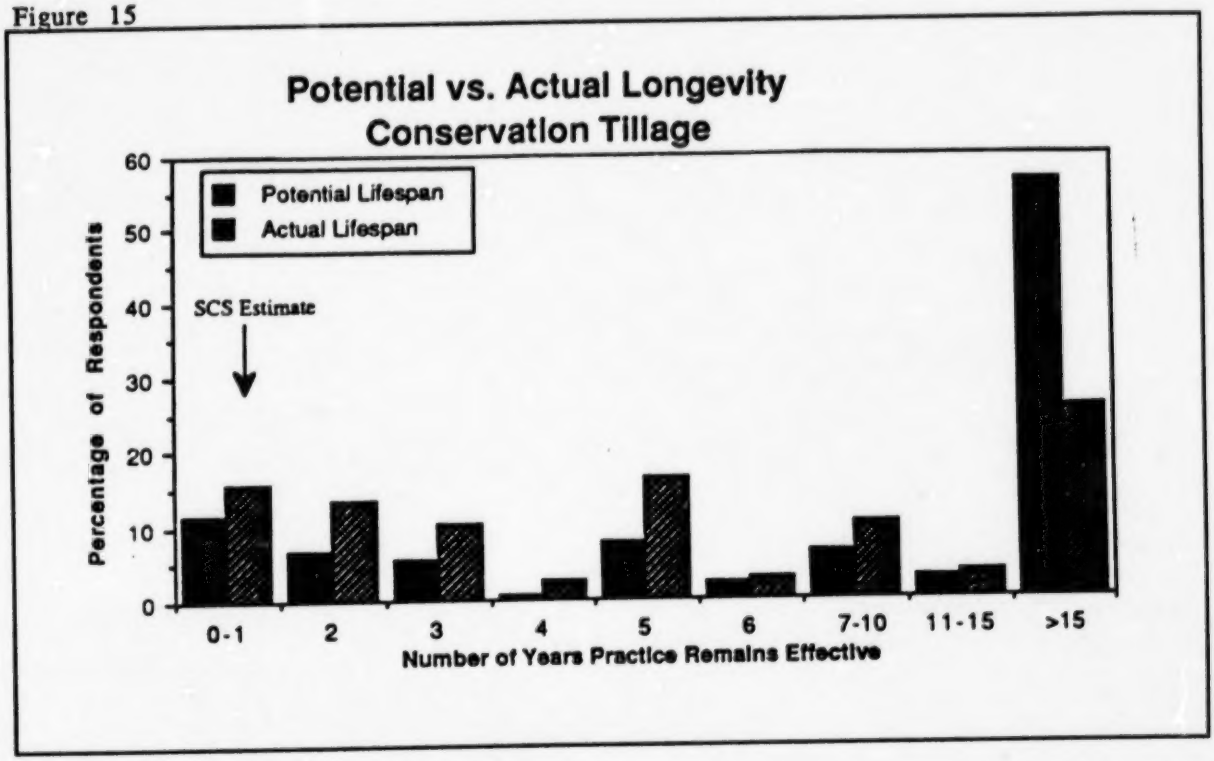
Research using dyes with an artificial rainfall simulator at Coshocton confirms previous research (Ehlers, 1975) that attributes the striking reduction in runoff to the higher infiltration rates existing in no-till soils. Macropores and worm holes, spawned by the BMP, are important channels for infiltration of rainfall.

These research endeavors show the theoretical potential of no-till or minimum-till to reduce runoff and enhance production over an extended period of time. Yet, the limited size of an experimental research station's study area, along with the ideal conditions which exist in a controlled

research environment may make results inapplicable for larger field conditions. A key issue, therefore, in the survey of local experts was whether a similar potential for no-till or minimum till longevity exists in a typical commercial context.

Survey results presented in Figure 15 validate the long term potential of conservation tillage. Over 50% of respondents feel that the practice can be utilized indefinitely (greater than 15 years). Only 10% consider it an annual practice. Not surprisingly, respondent's experience suggested that actual longevity falls far below the >15 year level and is widely distributed.

Figure 15



Inasmuch as conservation tillage is a different type of BMP than those discussed previously, the significant factors affecting its longevity are also different. Figure 16 indicates that education is the most important factor with soil type and crop also strongly influencing the practice's longevity. "Rented versus Owned" was not considered a major factor affecting operator willingness to continue reduced tillage systems.

While respondents were not asked about O&M activities, field visits revealed that this varies geographically, as do the reasons why operators discontinue no-till on a particular field. For example, in North Carolina, the appearance of Johnson Grass, a very aggressive weed for which no herbicide is presently available, effectively truncates a no-till cycle. At a minimum, operators will switch to conventional tillage until the problem is eliminated. The rumor of an anti-Johnson Grass herbicide was greeted with much anticipation by both local officials and farm operators in the state. This was one of the few areas where BMP longevity was affected by a "technological" barrier. Accordingly, appropriate herbicide usage is a key O&M activity for most no-till operators.

In Pennsylvania the reasons for discontinuing practices were somewhat different. Dairy operations generally only plowed to reseed alfalfa in straight fall plantings. Reduced tillage is widely used for corn and small grain. Thus, in practice, plowing of a strip occurs only once in six or seven years. This has little to do with any inherent dissatisfaction with no-till, but rather a need for more hay. In this case, the apparent decrease in practice longevity due to rotations may be desirable from a total resource perspective. In Ohio, until recently it was widely believed that no-till would not be possible in many areas of the state, due to soil type. In particular, farmers located in the poorly drained soils around Lake Erie only recently moved to any reduced-tillage systems. Hence, it is difficult to find operators with extended periods of no-till. Experts at the Coshocton Experimental Station acknowledge that periodically it may be necessary on these lands to break the no-till cycle with a year of conventional tillage in order to improve the grading of the land for drainage and weed control. It should also be noted that no-till on poorly drained soils has resulted in lower yields. over time. under research conditions. Experts at the Wooster Research Center station attribute most of the no-till cessation to loss of nerve. People panic when they see a few weeds or have a bad yield.

In addition, the following issues arose regarding No-till longevity during the field visits:

* A surprisingly large number of operations had relatively little residue on the soil surface five or more years after beginning no-till;

* Well drained silt loam soils in the experimental plots in Ohio, after 28 and 29 years of continuous no-till developed as dense and coarse platey structures in the old plow layer;

* These morphological changes in soil structure are also discernible in plots in which no-till only began recently.

* No till double cropping (i.e., soybeans in small grain stubble) was a common practice for economic reasons, rather than soil or water concerns;

* Surfase applications of nitrogen fertilizers may contribute to the rapid decay of residue, leaving the soil surfases relatively bare;

* If an operator is not fully committed to a comprehensive no-till system, the costs or availablity of a no-till planter may constitute an obstacle to a gradual transition;

* Enthusiasm for no-till was often a "generational issue." Skepticism is far greater among established operators who were raised on conventional systems; and

* For some "semi-retired" operators, no-till's net savings of time is not considered advantageous, as they already have an excess amount of leisure and "enjoy their time on the tractor."

In summary, conservation tillage appears to be a practice that can be maintained for a substantial period of time. While technically, agricultural operator's must decide each year whether to continue the system, there is no conceptual reason to consider this BMP an "annual" practice. Weed proliferation is the most common problem associated with reduced tillage in general. This can be resolved by periodic moldboard plowing, or more efficient herbicide usage.

V. Conclusions and Policy Implications

There is a tremendous range in the quality of BMP implementation among agricultural operators. This is reflected both in the variability found in the field observations and the disparity expressed by survey respondents between "potential" and "actual" longevity. In general, management practices to control runoff from agricultural operations can last for extended periods of time, often indefinitely. Estimates by the Soil Conservation Service for life-expectancy are better descriptions of the actual lifespan of BMPs found in the field, than potential BMP longevity. Hence, there is a legitimate basis for designing policies that will encourage maintenance of practices beyond present SCS estimated life-expectancy periods, not to mention the typical ten year contractual commitment required in most cost-

share programs. (Table 9 offers an example of typical life expectancies in several cost-share programs for the practices discussed in the study). Grassed waterways, however, may pose an exception in this regard.

Table 2. Expected BMP Longevity: Cost-sharing vesus SCS

BMP	SCS	NC	MD	VA	PA
Terraces/ Diversions	20	10	10	10	10
An. Waste Storage	20	10	15	10	10
Vegetative Strips	5	10	5	5	5
Grassed Waterways	15	10	5	10	10
Conservation Tillage	1	1	NA	3	5

There are many possible strategies which might be undertaken in this regard. While exploration of each goes beyond the scope of the present study, they are worthy of mention.

* Provide cost-share assistance for specific O&M activities. (sediment removal);

* Offer cost-share assistance for specific O&M materials (i.e., seed, lime, netting, concrete);

* Increase the specificity cost-share contract conditions stipulating active periodic repairs and inspections, rather than the present concept of not destorying a practice.

* Systematic evaluation by the funding agencies of practices and mandated maintenance.

* Enact tax incentives for documented maintenance of practices for the duration of a BMP's life or after a specified design or contractual period has expired;

* Offer state income tax deductions for purchase of heavy equipment used for BMP operation and maintenance (manure tanks, no-till planters); and

* Impose regulatory requirements to maintain practices.

The results suggest that longevity estimates should play a key role in cost-benefit estimates prior to promotion of a given BMP system. For example, the tens of thousands of additional dollars required to install a concrete animal waste system are probably not justified due to their relatively minor advantage in longevity over earthen systems. The dramatic disparity in costs is reflected in Table 10, containing EPA cost-estimates for different animal waste retention systmes. (U.S. EPA, 1987). In short,

Table 10. Typical Manure Storage facilities and costs

Type of Farm	Manure System Components	Total Costs*
Dairy		
90 milkers 20 youngstock freestall	50' x 80' x 10' Concrete Storage With Pushoff ramps and roof Equiment	39,578 3,080 14,168 4,774 **$61,600**
Dairy		
28 milkers 20 youngstock satanchion	40' x 40' Asphalt Pad with 8' Concrete headwall and earth sides Equipment	1,848 9,856 2,772 6,776 **$21,252**
Dairy Replacement 20 animals stanchion	37' x 37' x4' Concrete Storage Asphalted Baryard Runoff controls: holding basin 450' diversion	7,469 3,234 693 2,310 **$13,706**
Poultry Litter Stacking Site 20,000 broilers	40' x 40' Concrete Pads with earth berms	4,466 4,774 **$9,240**

*Costs updated to 1985 dollars.

consideration of long-term effectiveness should increasingly drive cost-share administrators' and NPS regulators' decisions.

Operation and Maintenance

Perhaps the most encouraging conclusion from the study is that for many practices, particularly those involving vegetative cover, the most important O&M activities do not require money at all. Precautionary measures to avoid herbicide spills, lift tillage equipment when approaching vegetative strips, plow with the terrace and prevent traffic on grassed waterways are basically passive, requiring only a minimum level of awareness and concern. As a result, administrators of cost-share programs should be stringent in enforcing contractual terms when BMPs are ineffective as a result of sloppy management.

Other O&M activities do require the active involvement of the landowners. Yet, far too frequently landowners appeared indifferent to O&M, preferring to allow the practice to disintegrate and then apply for new cost-share support. Many cost-share programs limit the government's level of participation in order to ensure that the operator has a personal sense of involvement and investment in a practice. Tax incentives offer the advantage of encouraging maintenance rather than simply putting a premium on BMP installation. Because the marginal effort involved in maintaining practices, relative to installing them, is so small, education can probably solve a large portion of existing O&M problems.

A well run cost-share or regulatory program can also instill the value of O&M among operators. An anecdote described by Alamance County, N.C.'s district conservationist, Ray Dorsett, is instructive. A grassed waterway funded under the state's cost-share program was quickly eroded due to the traffic of heavy farm equipment. Only after an on-site visit from the local district raised the possibility of contract cancellation did the farm operator agree to reseed a grassed waterway that had lost much of its vegetative cover. The many hours of backbreaking work involved in nailing down the protective net over the newly-planted sod was sufficient to change the participant's attitude towards O&M. From then on, the operator forbid his children and workers to drive down the remaining waterways on a tractor--the most convenient, but also highly destructive route.

The aforementioned policies are directed at the individual landowner, assuming that the farm operator will undertake the necessary maintenance. Yet, there are other "institutional opportunities" which are worthy of

exploration for facilitation of O&M. The case on the following page describes a unique program where a conservation district assumes the central role in maintaining water management practices. An institutional approach to O&M may be more efficient for certain BMPs than one that relies solely on individual operators. First, there are potential economies of scale which can be exploited, particularly when capital intensive heavy equipment is required. Second, there is an added advantage of certainty and the potential for prioritizing investment in maintenance to maximize water quality protection. Third, there are often specific skills and techniques which can be acquired when a specialized department develops expertise in this area.

One area where a conservation district or other centralized BMP support industry might play a key role in maintenance is animal waste management. Accordingly, in dairy intense regions, small support industries have already sprung up. Farmers hire them to assume responsibility for waste application. When a retention facility is to be emptied, these companies agitate, pump and spread the manure using state of the art equipment. Farmers enthusiastically consider the development a "win win" situation. The manure experts own equipment that the operator could never afford, and do the job in less time and for less money than they can. The new equipments' capabiltities of integrating manure into the soil during spreading provides key water quality benefits as well. Other areas where there might be room for institutional maintenance are integrated pest management scouting, terrace rebuilding, deep soil probes, waterway grading and reseeding of vegetative practices.

Implications of Factors That Affect BMP Longevity

It is extremely difficult to generalize about factors that affect BMPs as they are subject to such regional variation. Nevertheless, there are clear lessons from the study. For example, to that extent that the longevity of animal waste management is a function of the economic prosperity of an operation, only a policy of financial incentives (e.g., cost-sharing or tax incentives) will improve life expectancies. Yet, "environmental attitude," also considered by local experts to be a crucial factor in this BMP's longevity can be modified through educational interventions, public relations campaigns etc.

Similarly, according to the survey, conservation tillage longevity is largely a function of education, cropping system and soil type. Education can be supplemented through voluntary or regulatory programs, such as Central Platte, Nebraska Natural Resources District's mandatory fertilizer application classes. Intensive efforts with agricultural extension might also lead to improvement of the "environmental conditions" (e.g., crop and soil type) that

Ditch Maintenance By Conservation Districts

In 1957 Ohio passed a Maintenance Law in which County Commissioners were delegated authority to remove obstructions from water courses. In practice this authorized counties to maintain ditches at public expense. (Ohio Revised Code $6151.14) A later amendment (Ohio Revised Code $6137.15) authorizes counties to enter agreements with Conservation Districts to transfer authority and responsibility for maintenance to the districts. In 1971 Henry County Ohio entered into such an agreement with its Soil and Water Conservation District. The eighteen year experience offers an example of a promising institutional arrangement for furthering BMP maintenance.

The district has found that if they undertake the following O&M activities, there is never a need to rebuild ditches:

Annual:

(1) Inspection of ditch (during first year);
(2)Seed the ditch bank and or filter strip;
(3) Remove noxious weeds through herbicide usage;
(4) Spray to control brush (typically with rodeo, roundup);
(5) Check for and eliminate cattails problem within the ditches (roundup);
(6) Check banks for sliding and stabilize if necessary.

Periodic (Approximately Every Six Years):

(7) Deposition removal.

The extent of O&M activities to a large degree depends on soil type; heavy clay ditches require less maintenance than those in sandy areas. "Dipping" for sediment in a sandy area can be necessary as often as once every five years, while in the clay regions of the county, sediment removal has only been necessary every fifteen years. A 1981 amendment, requiring a four foot filter strip along the upper banks of the ditch, intended primarily as a safety precaution, has contributed greatly to the longevity of the ditches. The cost in forgone cropland to the area's farmers is minimal. (A 4 foot strip over a mile long distance is less than 1/2 an acre). On the sandy soils, filter strips should also be wider, with widths no less than ten feet.

In retrospect, the Henry District views their ditch maintenance program as an unqualified success. Neighboring Defiance County, Ohio after a similar arrangement with its District suspended the agreement and resumed control over ditch maintenance. Yet, the county offices lacked the commitment and knowledge of the district. As a result, the maintenance program fell into disarray. Today the commissioners plan to return the program to the hands of the District who are considered a more appropriate oversight organization.

The program also saves the public money. Utilizing sub-contractors the district can complete the most expensive O&M activity, deposition removal (or "dipping") at a cost of $1280/mile of ditch. This compares favorably with the costs of rebuilding a ditch which rose from $3,000/mi. in 1970 to $15,000/mi. today. Ongoing maintenance has proven to be reasonable, relative to the cost of intermittent reconstruction. For example, $4098 has been spent on maintenance for a typical ditch since it was built in 1967 at a cost of $3016. The cost-effectiveness of the O&M activities is without question. Yet, more important than the monetary advantages, the ditches in the county remain in excellent repair, continuing to serve their intended function for water management.

further conservation tillage longevity. In many places, operators recognized a lack of enthusiasm among local extension agents for no-till. Such attitudes must be overcome before operators can be expected to utilize this BMP.

BMP Longevity: Future Research Needs

To a large extent, this assessment should serve as a pilot study. By design it is not intended to be a strictly "scientific" investigation. Methodological purity was knowingly sacrificed to improve the study design while the investigation was underway. Randomization often gave way to purposeful stratification in order to increase the number of observations for a given practice. Even so, the sample sizes are too small to undertake extensive statistical analysis. While generating fairly crude data was a primary objective, substantive insights into this hitherto undeveloped field of research proved of equal importance. There are a number of areas that future research might explore that would improve present understanding of BMP longevity.

The methods for evaluating BMP longevity are useful, but ultimately should not be a substitutes for more quantifiable criteria (e.g., sediment, runoff, or nutrient reduction). Data, such as that produced at the Coshocton experimental station about long term no-till effectiveness is crucial if governmental agencies are going to make informed decisions that will improve water quality over the long run. Nevertheless, if a government agency wishes to have a better sense of how it is doing in the field, or even needs an objective basis for inspection of BMPs, the Urban Longevity Scale is a helpful tool.

Future research should attempt to better quantify the costs of different O&M activities. While intuitively, most appear to be extremely cost-effective, there is room for documentation in this regard. Certain factors that appear to affect BMP longevity need to be explored. For example, the relationship between income and maintenance is an important one which should be better understood. Not only would the results interest those concerned with issues of equity and financial burdens posed to small and less prosperous farms, but cost-share programs might modify their policies accordingly.

The good news is that BMPs can last for a very long time. The technological optimism cited by SCS and Conservation District technicians was confirmed during extensive on-site visits. Many BMPs installed over thirty years ago continue to do a good job, reducing sediment and runoff effectively. To the extent that policies can be designed that encourage the Operation and Maintenance and environmental conditions that preserve and repair practices, long term water quality prospects will improve.

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Appendix 1:

Name:
Affiliation:
Position
State:

BMP Longevity: A Questionnaire

Part One
Estimated Longevity:

Please estimate the potential and actual lifespan of each BMP on the basis of your experience.
* **Potential Lifespan:** Number of years practice will remain effective if properly maintained.
* **Actual Lifespan:** Number of years practice remains effective given typical maintenance.

For annual practices, estimate the number of years a practice remains in use once utilized.

(*Directions:* For each practice, make an x in one box per column.)

	Potential	Actual
1)Terrace		
a)0-2 years	☐	☐
b)3-4 years	☐	☐
c)5-6 years	☐	☐
d)7-8 years	☐	☐
e) 9-10 years	☐	☐
f)11-12 years	☐	☐
g)13-14 years	☐	☐
h)15-17 years	☐	☐
i)18-20 years	☐	☐
j)21-25 years	☐	☐
k)>25 years	☐	☐
2)Retention/Detention (Sediment) Basins		
a)0-2 years	☐	☐
b)3-4 years	☐	☐
c)5-6 years	☐	☐
d)7-8 years	☐	☐
e) 9-10 years	☐	☐
f)11-12 years	☐	☐
g)13-14 years	☐	☐
h)15-17 years	☐	☐
i)18-20 years	☐	☐
j)21-25 years	☐	☐
k)>25 years	☐	☐

Appendix 2:
Urban Longevity Scale and Evaluation Work Sheets

Specific physical characteristics of each practice are evaluated according to the following scale:

3: Good- Conditions are such that practice is operating close to original (new) specifications.

2: Fair - Maintenance is needed to bring back to original specifications. Not sufficient to seriously reduce practice effectiveness.

1: Poor - Serious loss from design specifications requiring immediate maintenance to return practice to original condition.

The following is a list of the characteristics evaluated for each practice, found on the evaluation worksheets.

Conservation Tillage

(1) Rills - shallow erosion channels crossing two or more rows.
(2) Cover Maintained - estimate of residue remaining on soil surface to protect from raindrop impact.
(3) Off-site Deposition - estimate of effectiveness of the tillage method determined by whether soil was moving downslope from the plot being evaluated.
(4) Cover Crop - A yes or no determination, a small grain stubble with double cropped beans was classified as a cover crop.

Grassed Waterways

(1) Percentage of Ground Cover - estimate of area of bare soil covered (protected) by vegetation. (More than 80% was rated to be in the "good" range).
(2) Outlets (stability)- adequate to dissipate the energy from the runoff without serious erosion damage to the channel or off-site.
(3) Channel Cutting - measure of concentration of flow causing removal of mineral material.
(4) Narrowing - reduction in the width of the design channel by encroachment of tillage equipment.

(5) Deposition - accumulation of mineral soil in the channel sufficient to obstruct sheet flow and/or smother vegetation.
(6) Crossing Damage - damage to the channel cross section or vegetative cover by tillage equipment or herbicides.

Vegetative Strips

(1) Percentage of Vegetative Cover - (See Grassed Waterway).
(2) Deposition - evidence of mineral soil movement within the strip.
(3) Rills - shallow erosion channels crossing two or more rows or six feet or more in vegetative strip.
(4) Strip Width Adequacy - whether soil movement was contained within the strip evaluated

Terraces

(1) Percentage of ground cover - (See Grassed Waterway).
(2) Outlets (stability) - runoff was as sheet flow which did not cause rilling or destruction of vegetative cover.
(3) Channel Cutting - channel bottom is stable.
(4) Narrowing - channel cross section is not affected by encroachment by tillage operations.
(5) Deposition- accumulation of mineral soil within the channel restricting free flow and or smothering of vegetative cover.
(6) Ridge Heights - estimate of the reduction of the ridge from original design by tillage.
(7) Cropping Direction - row and tillage direction in relation to the orientation of the ridge.

Animal Waste Storage (Concrete & Earthen)

(1) Adequacy of storage 0 design capacity and emptying schedule in relationship to how it is presently being used.
(2) Cracks - (Concrete) Spalling - deterioration of the concrete from stress or freezing.
(3) Deposition - buildup of waste in the lagoon which is not removed during pumping.
(4) Surface Water Control - runoff from outside sources other than holding areas for livestock is diverted.
(5) Footer Drains -drains around the structure to maintain the structural integrity (yes or no).

(6) Emptying Schedule - adequacy of the schedule for emptying as opposed to schedule used and observed level of filling.

(7) Gateway Seepage - in cases where manure is removed by loaders, (dry storage) rather than dumped.

(8) Slumping (Earthen) - settling of the mineral soil causing a reduction in capacity or affecting the structural integrity of the earthen fill.

U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FELLOWSHIP AGREEMENT

ASSISTANCE ID NO.
U-913045-01-0

NOTE: The Fellowship Agreement must be completed in original and one copy. The original must be returned to the Grants Administration Division within 3 weeks after receipt or within any extension of time as may be granted by EPA. Except as may be otherwise provided, no costs may be incurred prior to the execution of the Fellowship Agreement by both parties.
Receipt of a written refusal, or failure to return the properly executed document within the prescribed time, will result in the automatic termination of the fellowship offer by the Agency. Any amendment to the Fellowship Agreement by the fellow subsequent to the document being signed by the award official shall void the Fellowship Agreement.

GENERAL INFORMATION

PART I

1. FELLOWSHIP ADMINISTRATION DATA

a. STATUTE REFERENCE
Pesticides Act, Sec. 20

b. REGULATION REFERENCE
40 CFR, Parts 30 & 46

c. FELLOWSHIP PROGRAM
Special Part-time

2. APPROPRIATION AND ACCOUNTING DATA

a. APPROPRIATION
6890200

b. ACCOUNT NUMBER
9AHD41D000 $ 6,000

c. OBJECT CLASS CODE: 41.25 DCN: DC0003

3. AWARD APPROVAL OFFICE

a. ORGANIZATION
Off. of Policy, Planning & Eval.

b. ADDRESS
Environmental Protection Agency
Washington, DC 20460

4. ISSUING OFFICE

a. ORGANIZATION
Grants Administration Division

b. ADDRESS
Environmental Protection Agency
Washington, DC 20460

5. PROJECT OFFICER (Federal Contact)

a. NAME
Mr. Bruce A. Sidwell (PM-223)

b. TITLE
Project Officer

c. TELEPHONE NUMBER (Include Area Code)
(202) 382-5616

d. ADDRESS
Off. of Policy, Planning & Eval.
Environmental Protection Agency
Washington, DC 20460

6. FELLOW

a. NAME AND SOCIAL SECURITY NUMBER
Michael Hugh Habeck
261-49-6532

b. ADDRESS
3387 Woodmar Court
West Lafayette, IN 47906

7. SPONSOR

a. NAME
Dr. Stephen Lovejoy

b. TITLE
Associate Professor

c. TELEPHONE NUMBER (Include Area Code)
(317) 494-4244

d. ADDRESS
Purdue University
Dept. of Agricultural Economics
649 Krannert Building
West Lafayette, IN 47907

8. AMOUNT

a. TUITION AND FEES	PAID TO INSTITUTION	$ -0-
b. BOOKS AND SUPPLIES (May not exceed $750.)	PAID DIRECT TO FELLOW	$ -0-
c. STIPEND		$ 6,000
TOTAL AMOUNT OF FELLOWSHIP		$ 6,000

9. DURATION (Approved dates of fellowship; 12 months or less)
The duration of this fellowship will be 4 months.
This Fellowship must be activated within 6 months from date of award.

10. PAYEE (For Institutional Allowances)

a. NAME

b. TITLE
N/A

c. ADDRESS
N/A

11. FELLOW'S NAME AND ADDRESS (For stipend check)

a. NAME
Michael Hugh Habeck

b. ADDRESS
3387 Woodmar Court
West Lafayette, IN 47906

12. GRANTS SPECIALIST FOR THIS PROJECT

a. NAME
Betty Utterback

b. PHONE
(202) 382-5285